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Condition assessment of raking damaged bulk carriers under vertical bending moments

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Abstract. This paper concerns about the raking damages on the ultimate residual hull girder strength of bulk carriers by applying the modified R-D diagram (advanced method). The limited raking damage scenarios, based on the IMO's probability density function of grounding accidents, were carried out by using sampling technique. Recently, innovative method for the evaluation of the structural condition assessment, which covers the residual strength and damage index diagram (R-D diagram), was proposed by Paik et al. (2012). This concept is applied in the present study and modified R-D diagram, which can be considered vessel size effect, is then proposed. Four different types of bulk carrier structures, i.e., Handysize (37K), Supramax (57K), Kamsarmax (82K) and Capesize (181K) by Common Structural Rule (CSR), were applied to draw the general tendency. The ALPS/HULL, intelligent supersize finite element method, was employed for the ultimate longitudinal strength analysis. The obtained empirical formulas will be useful for the condition assessment of bulk carrier structures. It can also cover different sizes of the bulk carriers in terms of ultimate longitudinal strength. Important insights and findings with useful guidelines developed in this study are summarized.

Keywords: raking damage; bulk carriers; ultimate residual longitudinal strength; vertical bending moment

1. Introduction

Nowadays, ships are the main means of conveyance for various types of cargo due to active trade activities across the world. However resulting from these active trade activities, various types of accident - grounding, collision, fire and explosion - continuously occur even through there are many actions have been taken to prevent the loss of structures as well as environmental pollutions. Among those various types of accidents, grounding damage effects on bulk carrier structures are mainly discussed in this study. Historically, numerous studies related to grounding accident have been performed during the last 20 years in various approaches. For example, damage predictions (Simonsen and Hansen 2000, Simonsen *et al.* 2009), assessment of damaged ship (Paik *et al.* 2003), structural consequences (Zhang 2002), modeling of damaged structure (Paik *et al.* 2003),

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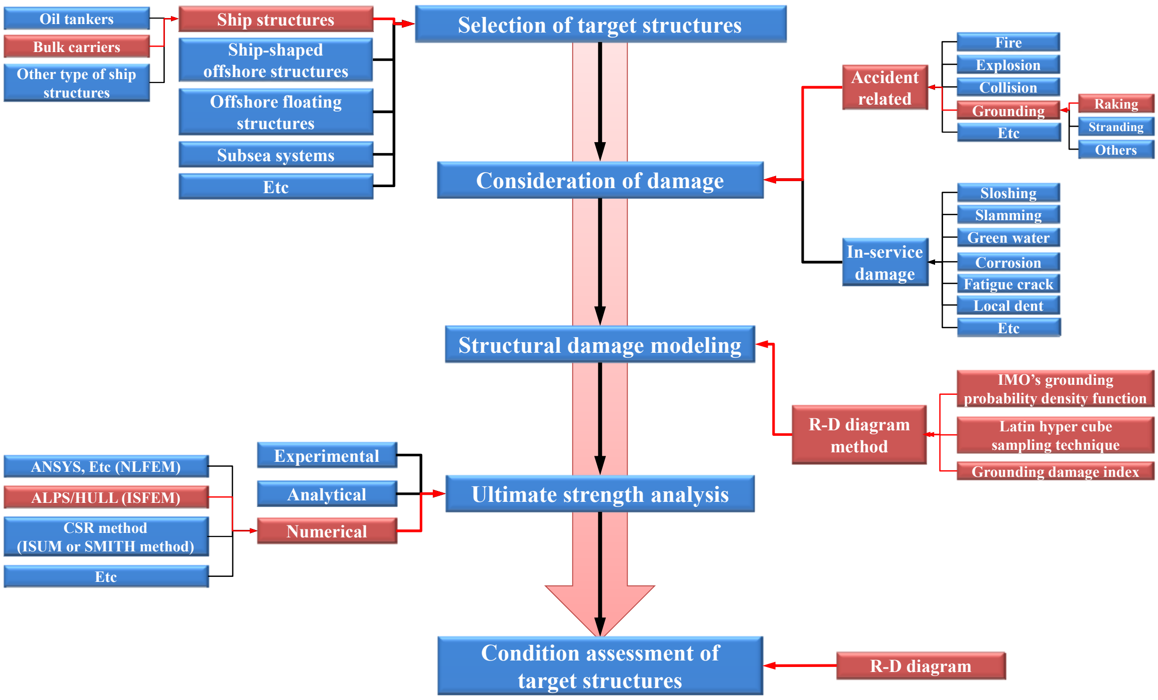


Fig. 1 Ultimate limit state based general condition assessment procedure with whole procedure of the present study (Red colored box) (Kim 2013)

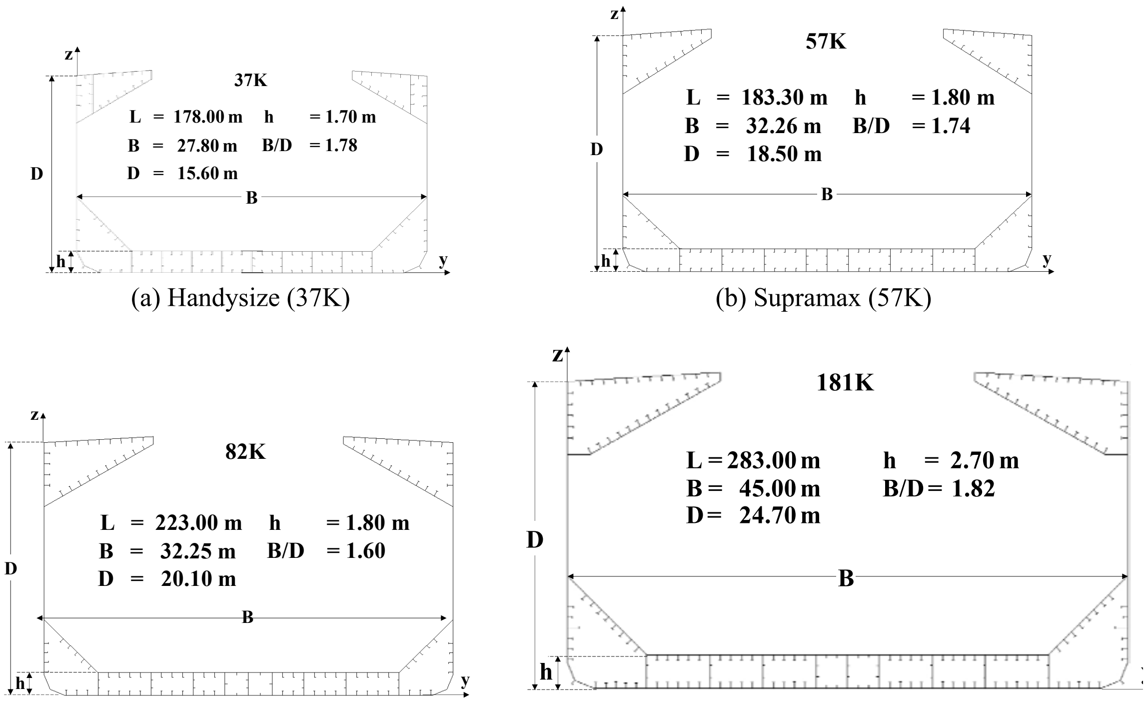
hull girder collapse (Pedersen 1994, Paik *et al.* 1998, Wang *et al*. 2000), structural designs (Ohtsubo *et al.* 1994), damage scenarios (Brown 2002, Paik *et al.* 2012), reliability (Luis *et al.* 2009) and others are already covered. Moreover, recent researches on grounding accidents by Samuelides *et al.* (2009), Pedersen (2010), Nguyen *et al.* (2011), Paik *et al.* (2012) and Kim *et al.* (2013a, 2013b) among others may also be referred.

The overall procedure of present study is illustrated in Fig. 1. In the present paper, section 2 covers the target structures. Raking damage modeling with details in terms of damage amount, damage location, number of damage scenario and others are presented in section 3. Also, ultimate limit state (ULS) based strength analysis has been carried out by applying the numerical method and R-D diagram is developed. The condition assessment of damaged structure can be performed based on obtained R-D diagram.

Finally, the modified R-D (Residual strength versus Damage index) diagrams (also called, simple empirical formulas) have been carried out to suggest the advanced method for condition assessment guidelines including vessel size, grounding damage, ultimate moment capacity. It will be useful to evaluate the structural condition in a short time.

2. Target structures

Four types of bulk carriers are selected for the target structures as shown in Figs. 2(a) to 2(d). These structures are designed based on the common structural rule (CSR) specified in IACS (2006).



(a) Handysize (37K) (b) Supramax (57K)

(c) Kamsarmax (82K) (d) Capesize (181K)

Fig. 2 Midship designs of applied bulk carriers (L=ship length, B=ship breadth, D= ship depth, h=double bottom height)

Table 1 Sectional properties for target structures

Types of bulk carrier	Section area (m^2)	Moment of inertia (m^4)	Section modulus (m^3) at bottom	Section modulus (m^3) at deck	Neutral axis (m)	Material properties (σ_Y)	Frame spacing (mm)
Handysize (37K)	2.765	103.240	16.876	10.432	6.117	AH32 & AH36	790
Supramax (57K)	3.372	180.852	25.913	15.037	6.979	AH32 & AH36	830
Kamsarmax (82K)	3.869	270.343	31.128	22.737	8.685	AH32 & AH36	960
Capesize (181K)	6.365	678.928	62.040	46.834	10.943	AH32 & AH36	925

Initial sectional properties with other information of each structure are also illustrated in Table 1.

3. Raking damage, structural modeling and analysis of target structures

3.1 Raking damage

Various accidents such as grounding, collision, fire, explosion of ships and offshore structures as shown in Fig. 1 are continued to occur regardless of efforts to prevent such accidents. In the present study, accident-related damage in terms of grounding is focused.

3.2 Review of R-D diagram method

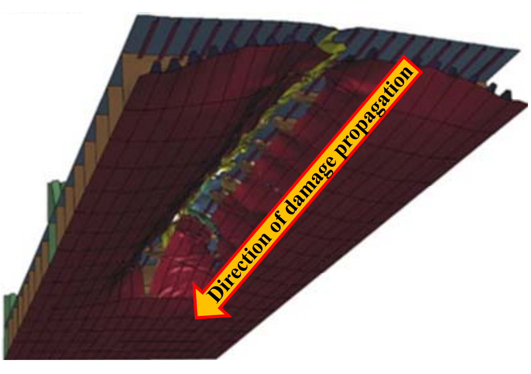
Paik *et al.* (2012) proposed innovative method for evaluating the structural safety by using Residual strength versus Damage index (R-D) diagrams. The proposed method can be applied to various types of damage for the structural condition and safety assessment. After the damage index (DI) is defined based on damage identification (i.e., damage type, damage amount, damage location), and then ultimate limit state based structural analysis can be performed to the selected reliable damage scenarios. The damage scenario selection should be carefully carried out to figure out credible damage condition based on sampling techniques. Once again, R-D diagram represents the relationship between damage indices and ultimate strength capacities. It can be applied to all types of structures and also be possible to adopt various types of damage.

In the previous study, R-D diagram concepts are proposed and the methods are verified of its applicability by applying the grounded double hull oil tanker structures. The applied structural analysis methods are covered in section 3.3.3.

Meanwhile, in the present study, raking damage, which is one type of grounding damages as shown in Fig. 3(a), on the ultimate longitudinal strength of bulk carriers based on abovementioned method are performed. The R-D diagram method can be summarized, as follows (Paik *et al.* 2012).

I. Structure characteristics
II. Damage parameters characterization
III. Damage scenarios selection by sampling technique based on probabilistic density distribution of each damage parameter
IV. Clear definition of damage index for selected damage scenarios
V. Residual ultimate strength calculation for selected damage scenarios
VI. Development of the R-D diagram (relationship between damage indices and residual ultimate strength calculation results)

The details of abovementioned method can be referred to Paik *et al.* (2012).



(a) Raking damage (Simonsen *et al*. 2009)

(b) Stranding damage (The Seattle Times 2008)

Fig. 3 Types of grounding damage

3.3 Application of R-D diagram

In the previous section, structural characteristics of four types of bulk carrier structure have already been defined. This section covers the applied results based on abovementioned six steps.

3.3.1 Damage scenarios

Grounding damage scenarios of target structures were selected based on the IMO's guideline (IMO 2003) as shown in Figs. 5(a) to 5(c) and the assumption from Paik *et al.* (2012) as shown in Fig. 5(d). They specified probability density functions in terms of various damage parameters as following x_1 to x_4. The explanation of damage parameters, i.e., x_1, x_2, x_3, x_4 are defined as follows, in respectively (Paik *et al.* 2012).

- x_1 - Grounding location in the direction of the ship's beam (y).
- x_2 - Height (H) of rock penetrating into the bottom of the hull in the direction of the ship's depth (z).
- x_3 - Breadth (d_1) of the bottom of the rock at the elevation corresponding to the ship's baseline and breadth (d_2) of the tip of the rock.
- x_4 - Angle of the rock (θ).

Now, the limited number of damage scenarios should be selected based on abovementioned damage parameters. In this study, fifty raking damage scenarios are selected to achieve the general tendency of structural behavior of bulk carrier structures by Latin Hypercube Sampling (LHS) techniques (Tang 1993). For the comparison purpose, the extracted damage parameters from fifty selected scenarios (histogram) are plotted together with original IMO's guidelines (solid line) as shown in Figs. 4(a) to 4(d). Details of explanation of damage scenario selection can be found in Paik *et al.* (2012).

Besides, numerous application studies of R-D diagram methods are recently performed e.g., grounded container ships (Kim *et al.* 2013b), comparison of structural analysis method (Kim *et al.* 2013a) and corroded oil tanker under grounding damage (Kim 2013).

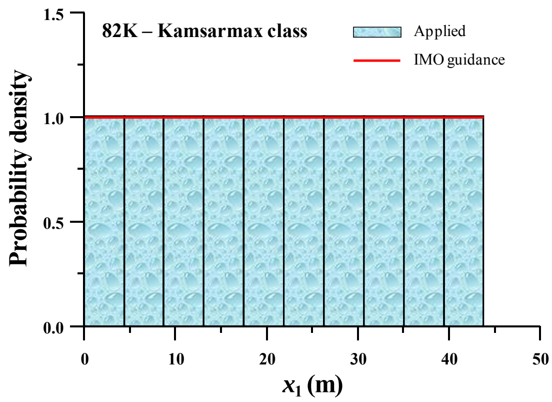
It is well known that reliable damage scenario selection is very hard. In addition, it is difficult to consider all damage scenarios for structural analysis. In this regards, only the fifty grounding damage scenarios are sampled through the Latin Hypercube Sampling (LHS) technique (Tang 1993) for the practical purpose. The selected scenarios are illustrated in Table A.1.

3.3.2 Damage index

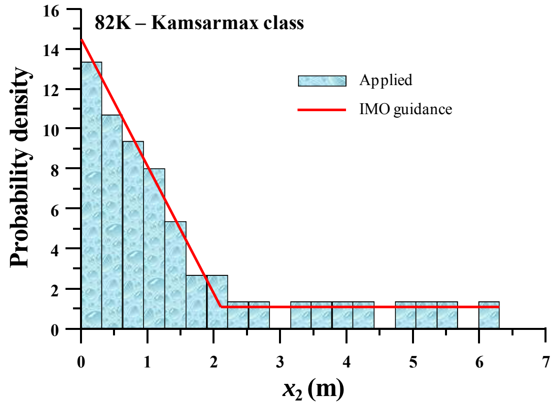
Prior to calculate the ultimate longitudinal strength of each bulk carrier structure, damage index due to grounding should be defined. In this regards, Paik *et al.* (2012) defined the grounding damage index (GDI) as follows.

$$GDI = \frac{A_{D\_OB}}{A_{I\_OB}} + \gamma \frac{A_{D\_IB}}{A_{I\_IB}} \tag{1}$$

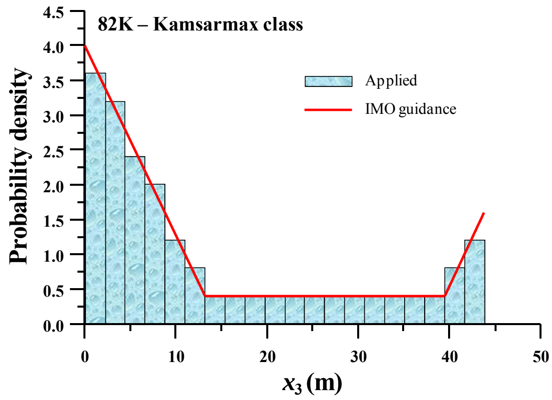
where, A_{D_OB} is the area of the outer bottom reduced by grounding damage, A_{I_OB} is the initial area of the outer bottom, A_{D_IB} is the area of the inner bottom reduced by grounding damage, A_{I_IB} is the original area of the inner bottom, and $\gamma = \theta_{IB} / \theta_{OB}$ = correction factor.



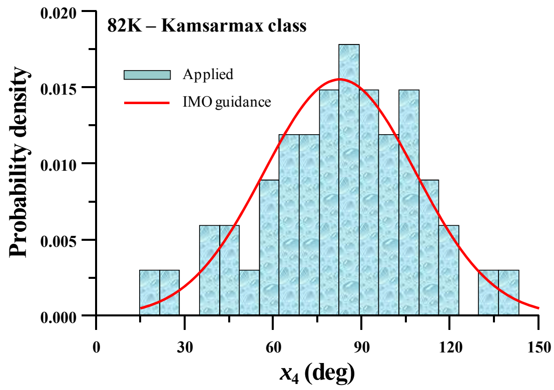
(a) Grounding damage location (x_1) (IMO 2003)



(b) Grounding damage height (x_2) (IMO 2003)



(c) Grounding damage breadth (x_3) (IMO 2003)



(d) Angle of rock (x_4) (Paik *et al.* 2012)

Fig. 4 Comparison between IMO grounding damage probabilistic density with applied typical example of Kamsarmax class bulk carrier (82K)

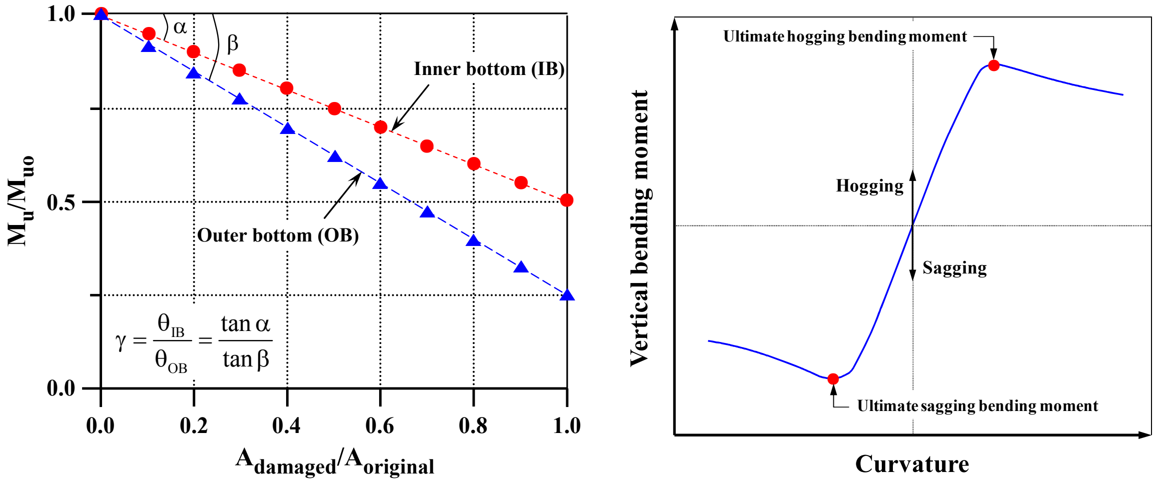
The correction factor is one of the important factors to calculate the GDI. It supplements the different influence of ultimate longitudinal strength due to outer bottom and inner bottom damage by grounding. Fig. 5 shows the definition of correction factor (left hand side figure) based on the ultimate longitudinal strength analysis (right hand side figure).

It can explain concretely that the each structural member (one plate and one stiffener) is gradually removed and ultimate strength analysis has been performed as shown in horizontal axis of Fig. 5(a).

Based on the calculated results, two linear best-fitted lines can be made in terms of outer bottom and inner bottom damage. Finally, correct factor can be calculated based on ratio of each line’s slope.

The correction factors (γ) of four types of the bulk carriers based on the abovementioned statement are illustrated in Figs. 6(a) to 6(d). The explanation of applied analysis method is presented in the next section. Finally, the calculated each fifty grounding damage index (GDI) is illustrated in Table A.2.

The generalized empirical formulas, for the purpose of user convenience about correction



(a) Definition of correction factor (b) Ultimate limit state

Fig. 5 Explanation of correction factor (Paik *et al.* 2012)

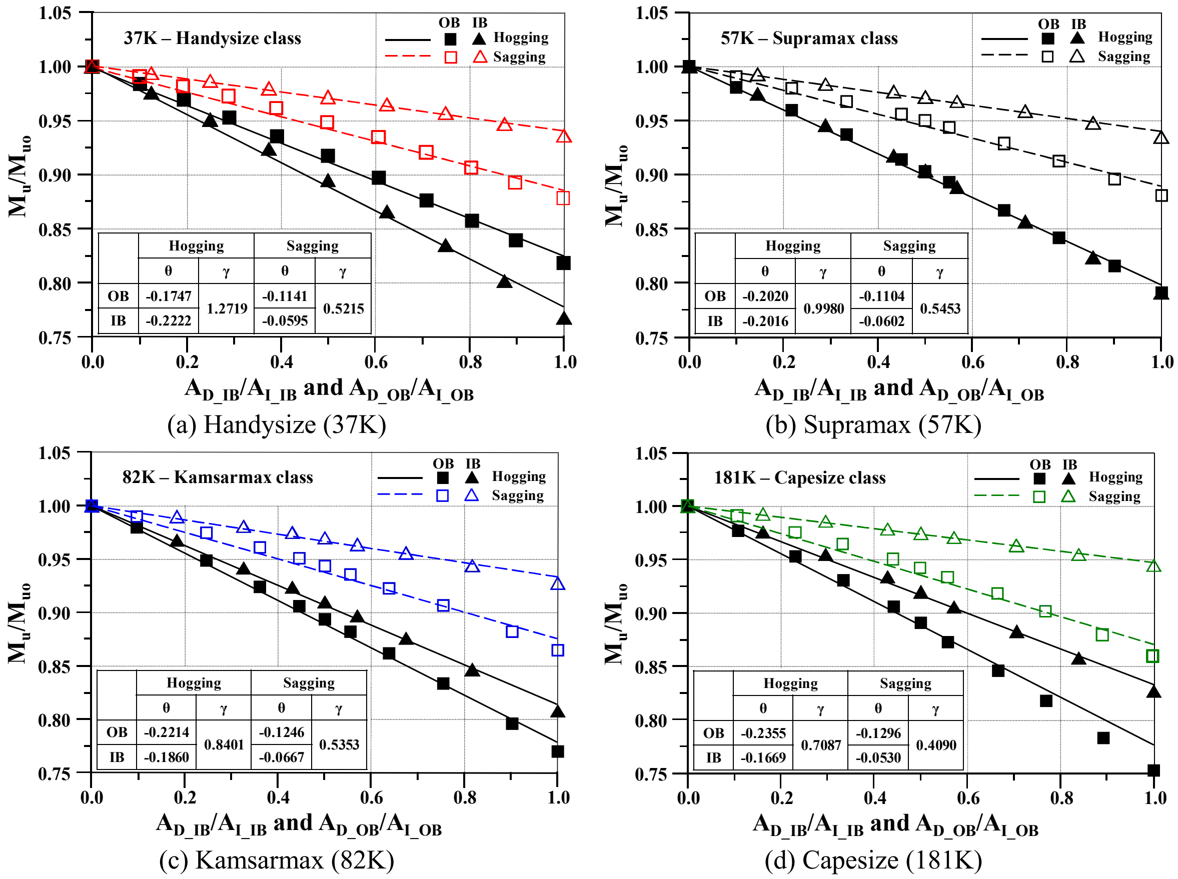


Fig. 6 Variations in the ultimate longitudinal strength of the bulk carriers with amount of grounding damage to the outer and inner bottom

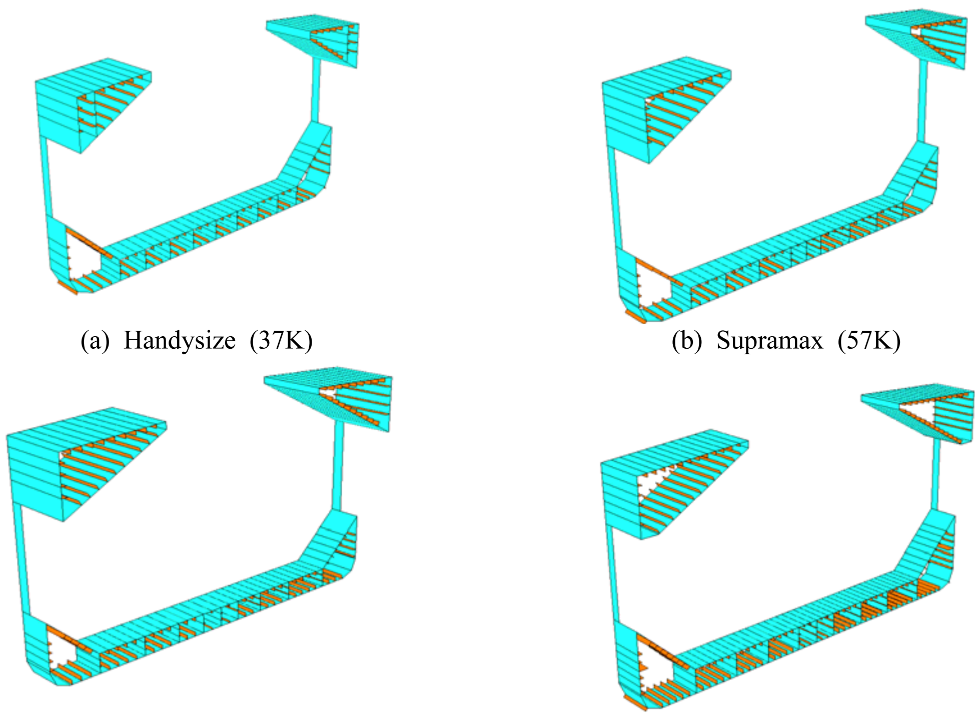
details are shown in Figs. A.1(a) and A.1(b) and the obtained empirical formulas can be present as follows.

$$\gamma = \begin{cases} -0.0044L + 1.9058 & \text{for hogging} \\ -0.0009K + 0.5844 & \text{for sagging} \end{cases} \tag{2}$$

3.3.3 Analysis of residual ultimate hull girder strength

In order to calculate the correction factor and ultimate longitudinal strength of bulk carriers based on fifty selected damage scenarios, progressive hull collapse analysis method (called, intelligent supersize finite element method, ISFEM) is adopted (ALPS/HULL 2012). There exist various methods to analyze the ultimate longitudinal strength performance of ships and offshore structures such as experimental, numerical and analytical method (Paik *et al.* 2012) as well as applied benchmark studies (Paik *et al.* 2013).

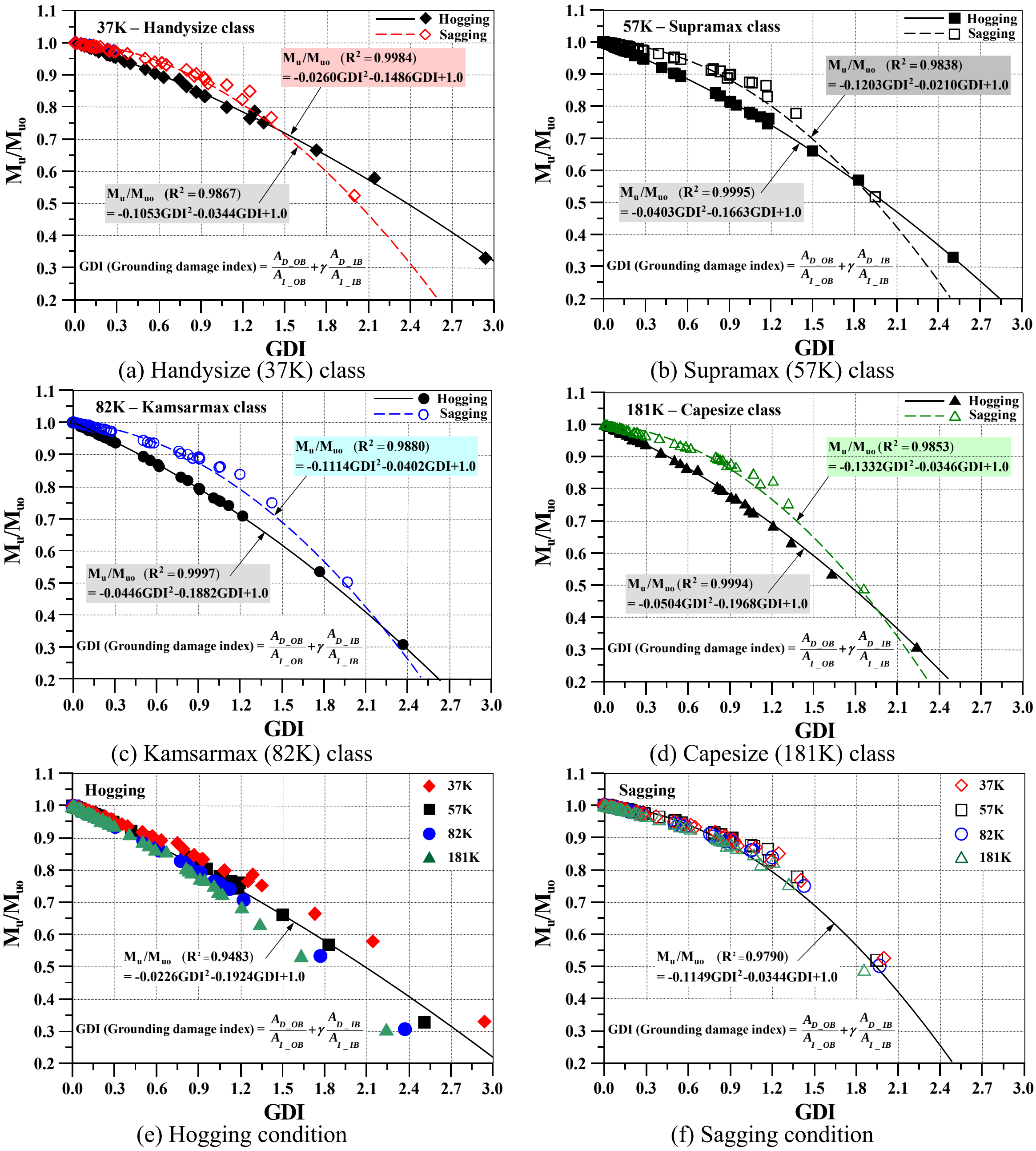
Paik *et al.* (2012) was adopted the modified Paik-Mansour formula method (design formula method) to prove the applicability of developed R-D diagrams. On the other hands, in this study, ALPS/HULL (2012) is adopted to obtain more accurate results. The comparison study between modified P-M design formula method and ALPS/HULL ISFEM were also performed (Kim *et al.* 2013a). In addition, application study of structural analysis for corrosion damaged double hull oil tankers are performed by Kim *et al*. (2012). The details of ALPS/HULL ISFEM theory are referred in Hughes and Paik (2010). The ALPS/HULL modeling for four types of bulk carriers are shown in Figs. 7(a) to 7(d).



(a) Handysize (37K) (b) Supramax (57K)

(c) Kamsarmax (82K) (d) Capesize (181K)

Fig. 7 ALPS/HULL ISFEM modeling of bulk carriers



(a) Handysize (37K) class (b) Supramax (57K) class

(c) Kamsarmax (82K) class (d) Capesize (181K) class

(e) Hogging condition (f) Sagging condition

Fig. 8 The R-D diagrams for bulk carriers

3.3.4 Development of R-D diagram (Empirical formula)

The residual ultimate longitudinal strength analyses, for the fifty grounding damage scenarios per each type of bulk carrier, are carried out and the GDI values are already calculated as shown in Fig. A.2.

The R-D diagrams, for four types of bulk carrier structures, are developed based on calculated GDI values and residual ultimate longitudinal strength as shown in Figs. 8(a) to 8(d). The empirical formulas (R-D diagrams), which are determined based on the curve fitting, are established based on the plotted fifty marks as shown in Figs. 8(a) to 8(d).

Based on the obtained R-D diagrams, the general trends of R-D diagram for bulk carrier hull structures, relating to hogging and sagging conditions, are expressed as shown in Figs. 8(e) and 8(f). From these R-D diagrams, condition assessment of other sizes of grounded bulk carrier structures except for applied four types of structures – 37K, 57K, 82K and 181K may also be performed promptly. Eqs. (3) to (7) shows the obtained R-D diagrams from Figs. 8(a) to 8(f).

For the Handysize (37K) class bulk carriers:

$$M_u / M_{uo} = -0.0260GDI^2 - 0.1486GDI + 1.0 \quad \text{in a hogging (3.a)}$$

$$M_u / M_{uo} = -0.1053GDI^2 - 0.0344GDI + 1.0 \quad \text{in a sagging (3.b)}$$

For the Supramax (57K) class bulk carriers:

$$M_u / M_{uo} = -0.0403GDI^2 - 0.1663GDI + 1.0 \quad \text{in a hogging (4.a)}$$

$$M_u / M_{uo} = -0.1203GDI^2 - 0.0210GDI + 1.0 \quad \text{in a sagging (4.b)}$$

For the Kamsarmax (82K) class bulk carriers:

$$M_u / M_{uo} = -0.0446GDI^2 - 0.1882GDI + 1.0 \quad \text{in a hogging (5.a)}$$

$$M_u / M_{uo} = -0.1114GDI^2 - 0.0402GDI + 1.0 \quad \text{in a sagging (5.b)}$$

For the Capesize (181K) class bulk carriers:

$$M_u / M_{uo} = -0.0504GDI^2 - 0.1968GDI + 1.0 \quad \text{in a hogging (6.a)}$$

$$M_u / M_{uo} = -0.1332GDI^2 - 0.0346GDI + 1.0 \quad \text{in a sagging (6.b)}$$

For the general bulk carriers:

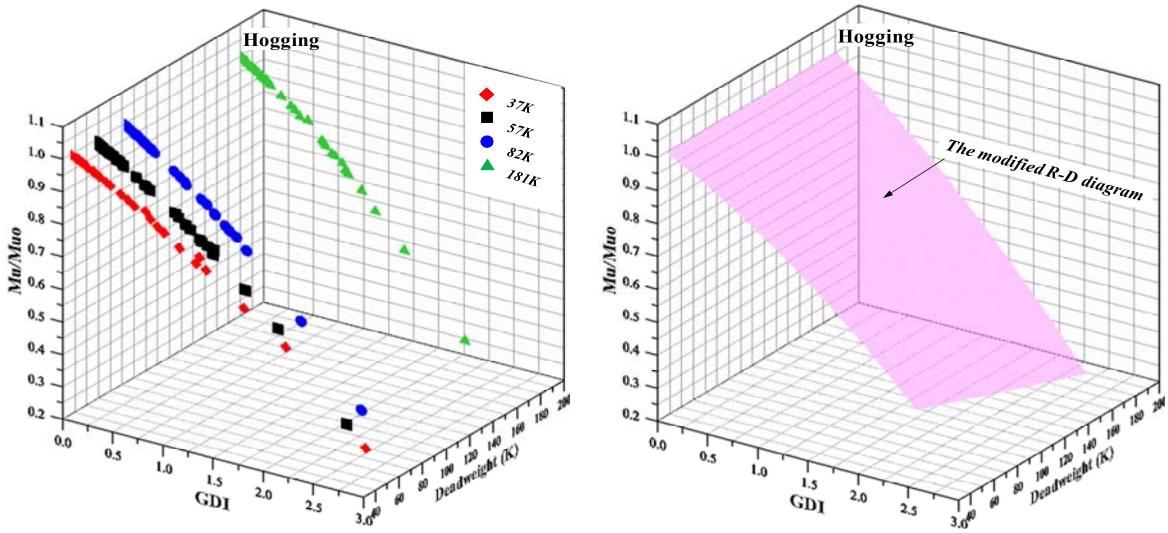
$$M_u / M_{uo} = -0.0226GDI^2 - 0.1924GDI + 1.0 \quad \text{in a hogging (7.a)}$$

$$M_u / M_{uo} = -0.1149GDI^2 - 0.0344GDI + 1.0 \quad \text{in a sagging (7.b)}$$

4. Application of R-D diagrams to different sizes of bulk carriers

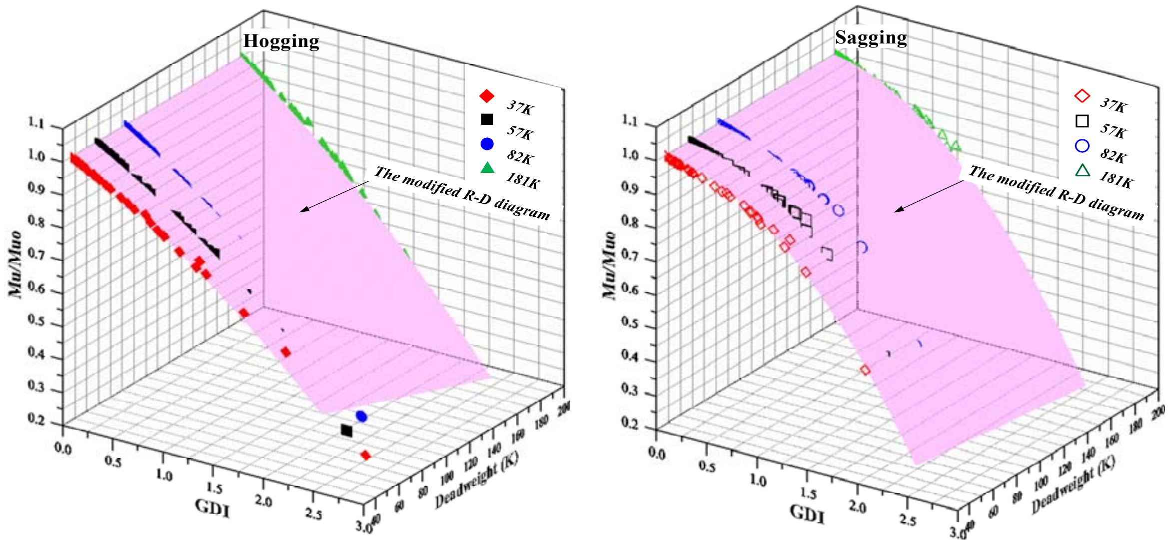
The R-D diagrams for bulk carrier structures are established as shown in Figs. 8(e) and 8(f). From here, coefficient of determination (R^2) under sagging condition as illustrated in Fig. 8(f) shows that the trends of R-D diagram are well fitted with calculated results ($R^2 \fallingdotseq 0.98$) but hogging trend as shown in Fig. 8(e) shows a little scattering as GDI increased ($R^2 \fallingdotseq 0.94$).

In this respect, the modified R-D diagrams (three-dimensional approaches) are suggested to improve the accuracy of R-D diagram by adding one more axis. The general ideas of the modified R-D diagrams are represented in Figs. 9(a) and 9(b). Of course, in the added axis, any types of parameters can be located. In the present study, deadweight (K) is applied based on the repeated benchmark studies.



(a) Plotted calculated results (b) 3-Dimensional approach by using curve-fitting

Fig. 9 Ideas of modified R-D diagrams (three-dimensional based) using curve-fitting



(a) Hogging (b) Sagging

Fig. 10 Modified R-D diagrams (three-dimensional based) for bulk carriers using curve-fitting

Based on the suggested 3-dimensional approach, the modified R-D diagrams are established as shown in Figs. 10(a) and 10(b) and their coefficients of determination ($R^2 \fallingdotseq 0.99$) are improved than the results of previous 2-D approaches. Finally, the modified R-D diagrams can be expressed as shown in Eqs. (8.a) and (8.b).

For the general bulk carrier structures:

$$M_u / M_{uo} = -3.171\times10^{-2}(\mathrm{GDI})^2 - 5.418\times10^{-4}(\mathrm{GDI})(\mathrm{K}) - 1.337\times10^{-1}(\mathrm{GDI}) + 1.183\times10^{-5}(\mathrm{K}) + 1.0$$
in a hogging (8.a)

$$M_u / M_{uo} = -0.171\times10^{-2}(\mathrm{GDI})^2 - 1.810\times10^{-4}(\mathrm{GDI})(\mathrm{K}) - 1.299\times10^{-2}(\mathrm{GDI}) - 1.560\times10^{-5}(\mathrm{K}) + 1.0$$
in a sagging (8.b)

5. Conclusions

In the present study, the R-D (residual strength versus damage index) diagrams to assess the condition of bulk carrier hull structures were established based on the R-D diagram method. Four types of bulk carrier hull structures, i.e., Handysize (37K), Supramax (57K), Kamsarmax (82K) and Capesize (181K), are considered to draw the general tendency of residual ultimate longitudinal strength of grounded structures. It is found that proposed R-D diagram method can be applied to raking damaged bulk carrier structures for the condition assessment. In addition, advanced method (modified R-D diagram), based on three-dimensional approach, is proposed to improve the accuracy of analysis result.

The effects of vertical bending moments are mainly considered in this study and effects of other types loading such as torsion, shear force and others will be performed for the further work.

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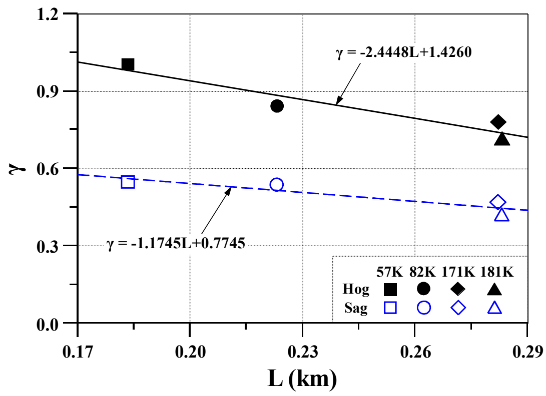
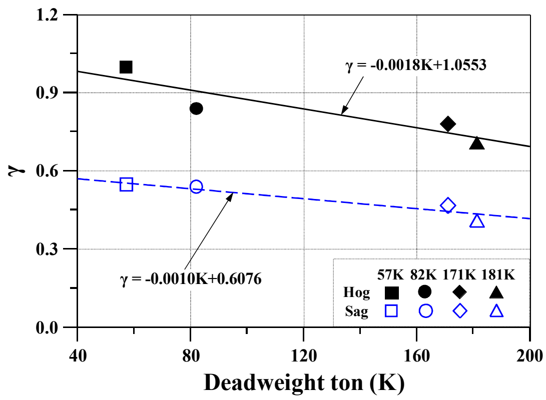
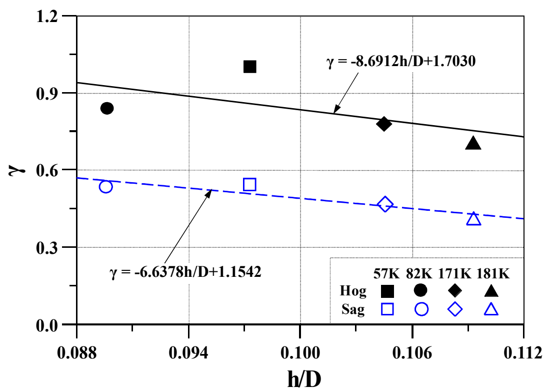
Appendix



(a) Length versus γ

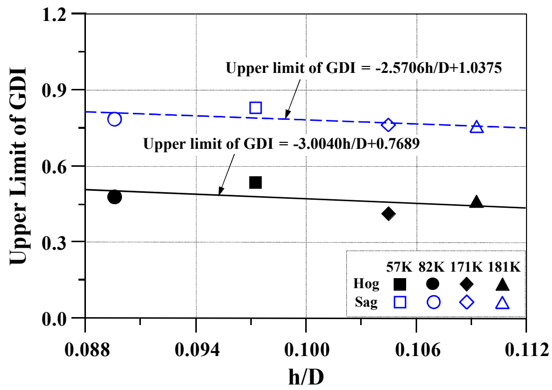


(b) Deadweight ton (K)

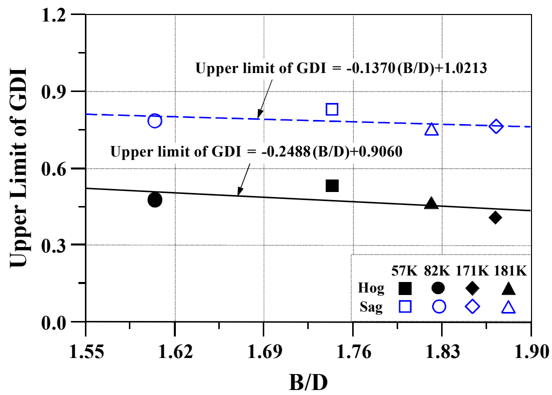


(c) h/D versus γ

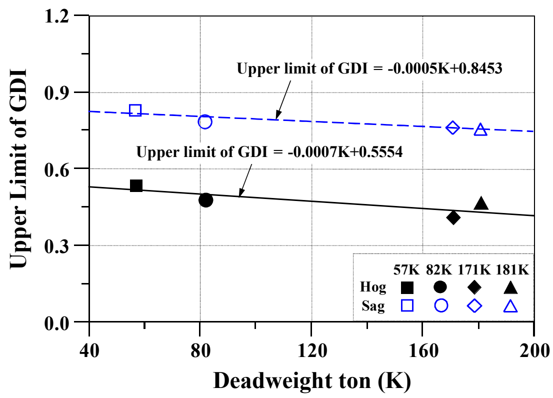
Fig. A.1 Trend of correction factors versus principal dimensions



(a) h/D versus upper limit of GDI



(b) B/D versus upper limit of GDI



(c) Deadweight ton (K) versus upper limit of GDI

Fig. A.2 The upper limit of GDI versus principal dimensions

Table A.1 The applied fifty raking damage scenarios with grounding damage parameters (Paik *et al*. 2012)

Scenario No.	Damage parameter			
	x_1(×B)	x_2(×B)	X_3(×B)	X_4
1	0.010	0.044	0.040	106.7
2	0.030	0.012	0.257	48.5
3	0.050	0.042	0.327	53.9
4	0.070	0.009	0.153	65.3
5	0.090	0.001	0.135	116.5
6	0.110	0.064	0.918	113.6
7	0.130	0.022	0.023	35.2
8	0.150	0.036	0.127	96.6
9	0.170	0.021	0.183	26.2
10	0.190	0.109	0.477	91.0
11	0.210	0.086	0.003	60.2
12	0.230	0.011	0.527	80.6
13	0.250	0.017	0.237	45.2
14	0.270	0.080	0.008	124.0
15	0.290	0.182	0.577	72.7
16	0.310	0.038	0.727	119.8
17	0.330	0.128	0.029	41.0
18	0.350	0.067	0.090	78.0
19	0.370	0.040	0.034	129.8
20	0.390	0.024	0.964	66.9
21	0.410	0.016	0.945	51.4
22	0.430	0.030	0.221	98.1
23	0.450	0.273	0.083	69.9
24	0.470	0.006	0.013	79.3
25	0.490	0.291	0.427	89.6
26	0.510	0.014	0.195	101.3
27	0.530	0.075	0.377	68.4
28	0.550	0.164	0.980	103.0
29	0.570	0.071	0.877	108.8
30	0.590	0.255	0.052	74.0
31	0.610	0.026	0.046	93.7
32	0.630	0.200	0.070	58.2
33	0.650	0.032	0.777	85.7
34	0.670	0.054	0.677	83.1
35	0.690	0.047	0.111	76.7
36	0.710	0.049	0.104	56.2
37	0.730	0.146	0.162	138.7
38	0.750	0.052	0.119	104.8
39	0.770	0.004	0.627	88.3
40	0.790	0.019	0.018	92.3
41	0.810	0.095	0.285	75.4
42	0.830	0.028	0.076	95.1
43	0.850	0.002	0.064	84.4
44	0.870	0.237	0.994	71.3
45	0.890	0.060	0.097	63.7
46	0.910	0.005	0.144	87.0
47	0.930	0.008	0.058	99.7
48	0.950	0.057	0.207	111.1
49	0.970	0.033	0.172	62.0
50	0.990	0.219	0.827	81.9

Table A.2 GDI values of the four types of bulk carriers for fifty damage scenarios selected

Scenario No.	Handysize (37K)		Supramax (57K)		Kamsarmax (82K)		Capesize (181K)	
	Hogging	Sagging	Hogging	Sagging	Hogging	Sagging	Hogging	Sagging
1	0.0000	0.0000	0.0084	0.0084	0.0001	0.0001	0.0050	0.0050
2	0.1017	0.1017	0.1260	0.1260	0.1663	0.1663	0.1254	0.1254
3	0.2306	0.2306	0.2506	0.2506	0.2440	0.2440	0.2388	0.2388
4	0.1017	0.1017	0.1025	0.1025	0.1240	0.1240	0.1113	0.1113
5	0.1017	0.1017	0.1260	0.1260	0.1240	0.1240	0.1254	0.1254
6	0.7942	0.7942	0.8058	0.7891	0.7750	0.7600	0.8109	0.8005
7	0.0080	0.0080	0.0247	0.0247	0.0345	0.0345	0.0216	0.0216
8	0.1442	0.1442	0.1585	0.1585	0.1646	0.1646	0.1591	0.1591
9	0.2382	0.2382	0.2293	0.2293	0.2253	0.2253	0.2131	0.2131
10	0.7465	0.6511	0.9563	0.7726	0.9082	0.7757	0.6713	0.6190
11	0.0000	0.0000	0.0236	0.0236	0.0088	0.0088	0.0142	0.0142
12	0.5000	0.5000	0.5029	0.5029	0.5038	0.5038	0.5033	0.5033
13	0.2885	0.2885	0.2901	0.2901	0.2751	0.2751	0.2615	0.2615
14	0.0080	0.0080	0.0075	0.0075	0.0001	0.0001	0.0076	0.0076
15	1.7271	1.1949	1.5034	1.1797	0.0000	0.0000	1.3425	1.1190
16	0.8661	0.8661	0.8381	0.8381	0.8271	0.8271	0.8480	0.8480
17	0.0779	0.0668	0.0310	0.0310	0.0310	0.0310	0.0424	0.0400
18	0.1146	0.1146	0.1361	0.1350	0.1214	0.1214	0.1175	0.1175
19	0.0433	0.0433	0.0546	0.0546	0.0370	0.0370	0.0455	0.0455
20	1.0840	1.0840	1.0535	1.0535	1.0563	1.0563	1.0721	1.0721
21	0.9322	0.9322	1.0697	1.0697	1.0454	1.0454	0.9452	0.9452
22	0.2749	0.2749	0.2829	0.2829	0.2759	0.2759	0.2977	0.2977
23	0.2258	0.1588	0.2236	0.1886	0.1909	0.1629	0.2027	0.1730
24	0.0080	0.0080	0.0034	0.0034	0.0052	0.0052	0.0168	0.0168
25	1.3499	0.9541	1.1284	0.8910	1.0107	0.8613	1.0422	0.8775
26	0.2476	0.2476	0.1943	0.1943	0.2062	0.2062	0.2182	0.2182
27	0.6333	0.6208	0.5159	0.5109	0.6099	0.5834	0.5912	0.5857
28	2.9394	1.9990	2.5124	1.9508	2.3682	1.9733	2.2362	1.8625
29	1.2493	1.2493	1.1819	1.1723	1.2240	1.2026	1.2078	1.2078
30	0.1656	0.1276	0.1305	0.1101	0.0940	0.0824	0.1100	0.0931
31	0.0662	0.0662	0.0620	0.0620	0.0531	0.0531	0.0542	0.0542
32	0.1697	0.1295	0.1578	0.1253	0.1822	0.1570	0.1448	0.1272
33	0.9227	0.9227	0.9102	0.9102	0.9112	0.9112	0.9103	0.9103
34	0.8661	0.8661	0.9156	0.9156	0.9054	0.9054	0.8300	0.8300
35	0.1456	0.1456	0.1533	0.1533	0.1152	0.1152	0.1306	0.1306
36	0.1123	0.1123	0.1166	0.1166	0.1418	0.1418	0.1303	0.1303
37	0.3518	0.2803	0.2912	0.2510	0.3057	0.2692	0.2619	0.2338
38	0.1442	0.1442	0.1720	0.1720	0.1651	0.1651	0.1371	0.1371
39	0.5696	0.5696	0.5534	0.5534	0.5584	0.5584	0.5450	0.5450
40	0.0080	0.0080	0.0310	0.0310	0.0088	0.0088	0.0218	0.0218
41	0.3950	0.3719	0.4190	0.3943	0.6213	0.5367	0.4048	0.3944
42	0.0985	0.0985	0.0856	0.0856	0.0861	0.0861	0.0796	0.0796
43	0.0591	0.0591	0.0793	0.0793	0.0772	0.0772	0.0652	0.0652
44	2.1436	1.4072	1.8331	1.3840	1.7664	1.4324	1.6329	1.3192
45	0.1017	0.1017	0.1431	0.1431	0.1469	0.1469	0.1152	0.1152
46	0.1017	0.1017	0.1260	0.1260	0.1445	0.1445	0.1331	0.1331
47	0.0419	0.0419	0.0445	0.0445	0.0687	0.0687	0.0681	0.0681
48	0.1542	0.1542	0.1860	0.1860	0.1996	0.1885	0.1834	0.1729
49	0.1203	0.1203	0.1254	0.1254	0.1119	0.1119	0.1229	0.1229
50	1.2843	0.8534	1.1934	0.9017	1.1213	0.9115	1.0136	0.8133